

The Truth That Makes Us Free

SCIENCE AND HUMANISM

By MICHAEL E. DE BAKEY

IN their purest forms, science, the systematic search for factual knowledge and natural law, and humanism, the concern for human welfare, are interdependent. Recently they have been at odds, assigned to "two cultures," though the debate actually began in the seventeenth century. But I prefer to think of science as disciplined thought and therefore to include the humanities with the sciences in one intellectual category. Admittedly, their approaches to truth differ, the one by observation and experimental testing, the other by philosophic thought. But so do the approaches to physical and biologic sciences differ, in degree of objectivity and precision, for example. These differences I do not consider incompatible.

Historically, the scientist and the humanist have common bonds. Medicine, art, and religion were closely allied in ancient times, when the medicine man was priest and artist. Western man brought home from the crusades a rich store of Arabic-Hellenic learning based on reason. Christianity combined with Greek logic to give a new meaning to theology. Alfred North Whitehead has traced "the motive power of research," which he defined as the "inexpugnable [medieval] belief that every detailed occur-

rence can be correlated with its antecedents in a perfectly definite manner" to "the medieval insistence on the rationality of God. . . ." "In Asia," he explained, "the conceptions of God were of a being who was either too arbitrary or too impersonal for such ideas to have much effect on instinctive habits of mind. Any definite occurrence might be due to the fiat of an irrational despot, or might issue from some impersonal, inscrutable origin of things. There was not the same confidence as in the intelligible rationality of a personal being. . . . The faith in the possibility of science, generated antecedently to the development of modern scientific theory, is an unconscious derivative from medieval theology."

The Renaissance brought parallel rebirths of art, literature, and medicine. The artists, in fact, were the leaders of medicine. After a separation of medicine and art during the Middle Ages, they united in the Renaissance, when artists first began representing the human body with mathematical precision. Medicine shifted from an alliance with magic, which arose from its origin in fear of the unknown, to an alliance with art and a study of the anatomy and function of the human body. Disease was no longer viewed as the vengeance of a punitive, wrathful deity, but as a disturbance of Nature. The artist, Leonardo da Vinci, became an anatomist, and the physician, Vesalius, an artist. The door was closing on the dogmatism of Galen and Avicenna and on intuition and analogy as a basis for knowledge, and was opening to direct scientific observation and exploration, as practiced by Copernicus, Vesalius, and Paracelsus, and thus eventually to modern science. In addition to his studies of anatomy, Leonardo da Vinci deduced principles in physiology, cardiology,

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and ophthalmology that paved the way for Harvey and others, and he displayed an amazing knowledge of engineering and mechanics. Michelangelo probed human dynamics and the anatomic structure of bones and muscle, and medicine, through art and artistic techniques, was on its way to becoming a science.

The most powerful force in the development of civilization, science has had a tremendous impact on man's phylogenetic status and on his view of himself in relation to the universe. In primitive times man's chief concern was his relation to God; during the Renaissance, his relation to Nature; and today his relation to his fellow man. In the evolution of this shift in interest, man has discovered ways of removing or controlling elements in Nature that are evil, threatening, painful, or uncomfortable to him and his fellow human beings. His interests have become more and more humanistic, largely through the impact of science.

The humanistic aspects of science have been responsible for progressively elevating modern man above paleolithic man and animals. In ancient times, self-preservation and self-protection held tribes together, their communality ruled by fear. Primitive man worshipped the sun because he feared the sun. Emancipated from this fear by science, man has sought more and more knowledge about his world, to make it less formidable and more hopeful for his progeny. Modern man has become intelligent enough and bold enough to explore the heavens—a feat primitive man would have considered not only impossible but imprudent. Nature, once feared as a chaotic force manipulated by witchcraft and complicity with evil spirits, is now viewed as an ordered phenomenon governed by physical laws, some of which man can control. Scientific knowledge has contributed abundantly to the conversion of the wrathful gods of paganism to the loving God of Judeo-Christianity. In seeking order, reason, and meaning in Nature and life, the scientist has merely been trying, like Milton in *Paradise Lost*, to understand and explain the ways of God to man.

The argument that science lacks human values and that this deficiency creates a

schism with humanism is fallacious. Those who see only the impersonality of science restrict their views to the means, not the end. For the true scientist fuses knowledge with wisdom, and although objectivity and impersonality are essential to his achievement of knowledge and truth, human values and sound judgment are equally essential in the use to which he puts his new knowledge. This union of knowledge and wisdom is the goal of education.

The conclusion that science is evil simply because some of its products may be converted to destructive ends by madmen, and the demand that it must therefore be stifled, are the quintessence of anti-intellectualism, which will surely lead to the very destruction that the opponents of science fear. Of course, scientists produced our atomic weapons, but we must remember that their research was prompted by an imperative need—to go beyond Germany's advances in nuclear research—and we must remember too that an international body of scientists influenced the treaty to ban atomic tests. E. J. Boell, in an article entitled, "Science and Liberal Education," has posed the telling question:

But I should like to ask whether it can reasonably be contended that those who produced the means of atomic warfare have been responsible for creating the problems which now face the world? The answer is "no." The scientists have not created a new problem. "They have," in the words of Einstein, "merely made more urgent the problem of solving an existing one." But even if we accepted the charge that scientists are responsible for the present dangers to mankind and to civilization, whom are we going to blame? Shall we pillory Seaborg, and Fermi, Rabi, Conant, and Bush? What shall we do with Nils Bohr who drew for us the picture of the atom? Or with Einstein whose genius perceived the mathematical relationship between matter and energy? And what of those who developed the aircraft by means of which delivery of the bomb was possible? Shall we bring Dædalus and Icarus to scorn for making man dream of the glories of flight, or Leonardo for bringing it nearer reality, or the hundreds who failed before the success at Kitty Hawk?

Norman Foerster, the well-known humanist, put it slightly differently when he addressed

himself to the antagonists of science to explain that the origin of earthly ills is "not in any material structure raised by the genius of man, but in the deepest depths of the human soul where selfishness and greed, hatred and fear have displaced beauty and goodness! . . . The evil from which we suffer lies in the realms of the humanities. It was not caused by scientists and engineers and will never be destroyed by them."

Thomas Huxley has explained the fear some have of science on a historical basis. To our ancestors nature was the domain of the devil, and anyone who tried to interfere with it was his associate; the scientific investigator, then, was a sorcerer. Remnants of the old beliefs and superstitions have filtered through the ages to modern times.

The community of scientists is bound by the common goal of exploring the truth. In the pursuit of this goal, certain values inevitably emerge—aesthetic, intellectual, ethical, moral, social, and cultural. The aesthetic values are evident in the scientist's appreciation of symmetry, correspondence, likenesses among differences, and of truth, which Keats perceptively equated with beauty. That science, like the humanities, has an aesthetic aspect is surprising to some, but not to those who have experienced the delight of a carefully conceived scientific theory or experiment, or a carefully established proof. Few things are as offensive and frustrating to a scientist as gaps in knowledge and few things as pleasant and exciting as fitting theory to fact. Science is not a catalogue of isolated facts, but an orderly, logical synthesis of related facts to produce new knowledge. It is the continual questioning, testing, evaluating, and revision of ideas. The scientific process of inquiry, discovery, and invention, like the artistic process, is creative—creative of a new concept, a new relation, a new experiment, a new product. The scientist derives personal satisfaction in such creation, but service to mankind is the ultimate value of science.

The primary ethical value that science has contributed is, in the words of Jacob Bronowski, "the habit of truth." The scientist's refusal to allow friendship, material wealth, or other considerations to interfere with his

objective separation of the true from the false and the illusory nurtures self-discipline, honesty, and integrity. This practice transcends national, social, economic, cultural, religious, and political differences, removing these barriers to human understanding. Scientists from hostile nations have been able to meet on the most amicable terms to exchange ideas, information, and knowledge and to impart skills to their foreign colleagues. This amicability can, and often does, extend beyond the intellectual level to dissolve personal, national, and international hostilities born of ignorance, greed, or vanity.

The scientist's intellectual values are illustrated in his respect for reason, scepticism, and dissent; his social values in his reverence for human life and human dignity and his tolerance and compassion for others; and his cultural values in his dedication to human enlightenment and development and in his measurement of reality against a theoretic standard. His demand for independence of man is tempered by his regard for the welfare of men. The intellectual freedom that he prizes so highly fosters respect for the ideas of others, even when they differ from his own. Dialectic, a keystone of modern science, is practiced in a calm, rational, unemotional atmosphere. Modern science knows no persecution like that of Giordano Bruno and demands no recanting such as that exacted of Galileo. The values of the scientist—truth, honesty, tolerance, freedom of thought and speech, respect for human life and human dignity, justice and compassion—are the highest values of humanity.

Human values are created only in communal living—when men living together discover that their individual drives and needs conflict with the social needs. The scientist, guided by human values, preserves his independence without compromising communal welfare or universal ideals. The insistence on verification of one researcher's experimental evidence and observations by others presupposes honesty and integrity among scientists. Scientists live in a stable community of free, honest inquiry, speculation, and debate, untethered by prejudice or authority and marked by open communication, collab-

oration, and mutual respect. Like the whole of society, the body of scientists has devised a code that merges the private with the public needs. There is no place in science for the dishonorable, the bigoted, the selfish, the mercenary, or the inhuman, and when these are bold enough or fatuous enough to try to enter the scientific community, they are quickly exposed and expelled.

Both the humanist and the scientist are critics of the human condition, but the methods and results of their criticism differ. The humanist expresses his observations and dissatisfactions verbally—in direct, symbolic, or allegoric language. The scientist acts to improve or correct the imperfections, limitations, or deficiencies he observes. The poet provides emotional and aesthetic pleasure in his lyrical treatment of the conditions and tragedies of life and of the inevitability of death, whereas the scientist seeks ways of mitigating anguish, pain, or discomfort and of preventing premature or unnatural death. In the words of C. P. Snow, “. . . the greatest enrichment the scientific culture could give us is . . . a moral one. . . . The impulse behind the scientists drives them to limit the area of tragedy, to take nothing as tragic that can conceivably lie within men’s will.”

Scientists are simple, humble, compassionate men who are aware of the limitations of the human mind, but who are dedicated to the expansion of human knowledge for the benefit of society. The scientist, therefore, subscribes to the doctrine of humanism, which focuses on human values and human welfare. A good scientist is, in fact, first a humanist and second a scientist. He does not allow his thirst for knowledge or his efforts to control his environment to subvert his humanitarian purpose. Our world is full of wonderful—sometimes awesome—instruments, machines, vehicles, and other products of scientific and technologic ingenuity, but these physical objects must always be subordinate to the welfare of the human race. Contemporary preoccupation with materialism and glorification of gadgetry do not entice the true scientist from his basic, humane instincts.

The humanistic effects of science are incalculable. Science is ubiquitous; it pervades

our lives and our civilization. It is a way of thinking and of solving problems, and its products are a way of life. Even those most resistant to new scientific concepts accept and enjoy—indeed would not relinquish—the technologic fruits of these concepts. Who among you would exchange places with the generation of our forebears who could not enjoy a book, make a telephone call, drive an automobile, take a plane trip, or hear a symphony at home? Who would surrender modern medicine, sanitation, lighting, transportation, refrigeration, air conditioning, heating, and automation? The material stability established by science has created a wholesome environment for the intellectual, social, and spiritual development of man. With greater affluence, man has been able to express love, respect, compassion, and kindness for his fellow being in materialistic ways that have extended the security of health, comfort, and well-being to more of the population than ever before.

In addition to providing comforts, conveniences, and measures for health and safety, science has in many other ways strengthened man’s understanding and control of himself and of natural forces around him. The ancient evils of life—hunger, poverty, ignorance, disease—which breed unhappiness, social turbulence, and crime, are all susceptible to alleviation or mitigation through science. And through science new problems will be conquered: the population dilemma, the threat of inadequate food and water, air and water pollution, vehicular accidents, and undeveloped human intellect and skills. Science knows few boundaries; it embraces not only physical and biologic disciplines, but psychologic, social, and philosophic studies as well. All contribute to man’s understanding of order, his enjoyment of beauty, his recognition of meaning, and his comprehension of truth.

Medical science probably illustrates most palpably the humane goals and products of research. Dedicated to the prevention of disease, the relief of suffering and disability, and the prolongation of life, medical science provides for the comprehensive physical, emotional, and social morality of man. The World Health Organization has defined

health as, "a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity." This nonpolitical organization dedicated to the improvement of health care throughout the world vividly exemplifies the humanitarian interests of medical scientists. As Disraeli said, "The health of the people is really the foundation upon which all their happiness and all their powers as a state depend." In helping less progressive nations, improvement of health standards deserves priority, since health is the cornerstone upon which human achievement depends. A people debilitated or incapacitated by infectious, nutritional, parasitic, or other disease can hardly acquire the knowledge or develop the skills required for the economic, educational, industrial, sociologic, cultural, or scientific advancement of a nation.

The achievement of universal health presupposes scientific inquiry, which in turn requires support, opportunity, and freedom. The expansion of medical knowledge is governed by the attitude of society. Today's enlightened people are curious about the activities and advances of medical science; only by satisfying this curiosity can we hope to gain their recognition of the universal benefits of science to human health. Through education, our society is becoming more and more aware that it is responsible for the health and welfare of all human beings, and that health is not a privilege or luxury for the few, but a right and a necessity for all.

Since 1800, Medical research has doubled the average life span, then only thirty-five years in this country, and has given us the highest standards of health and sanitation man has ever known. It has permitted correction of previously fatal congenital and acquired heart diseases, eradication or control of certain forms of cancer, early detection and prevention of strokes, conquest of poliomyelitis, pneumonia, and many other fatal infections, and rehabilitation of the emotionally and mentally ill and the physically incapacitated. Diseased tissues can now be repaired by synthetic products, and non-functioning limbs can be replaced by mechanical substitutes. The artificial heart-lung machine is used daily in operating rooms to help cir-

culate the blood during repairs to hearts and circulatory systems, and the artificial kidney sustains the lives of certain patients with renal diseases. Medical scientists are now vigorously working to perfect transplantation of whole organs and to develop artificial organs. Many of these realities or near-realities were considered only a quarter of a century ago to be fanciful ideas of visionaries. Even now we are on the threshold of a biomedical revolution with the key of life and the genetic code of cellular biology close within our reach.

Just as the practical value of science is often obscure, so its transcendent humanistic significance is often subtle. Science has not only provided physical and material comforts but has cultivated reason, lifted the human spirit, and allowed man to achieve his highest role in life. The method of scientific inquiry disciplines the mind to conquer the inner temptations and outer pressures and to make rational, dispassionate decisions. Freed by reason from prejudices, caprice, fears, superstitions, and dogmas, man can better approach his goal of making ours the best possible world—a world of unity of brotherhood, physical and mental comfort, and spiritual serenity—a world in which every human being has a fair chance of fulfillment. The collaborative nature of modern science teaches researchers to work together harmoniously, not only within an institution, community, or nation but throughout the world—to understand and respect the views and opinions of their associates especially when divergent from their own. This mutual respect improves not only interpersonal but international relations. All men have essentially the same goal—an even better understanding and control of life—and science can help them work together toward this goal and to resolve conflicting views rationally rather than destroy one another senselessly.

Science is a highly organized, integrated, dynamic structure. Its branches are diverse, but widely disparate components can be combined in unusual ways to yield remarkable fruits. Apparently impractical or trivial findings may be potentially useful. Every new fragment of knowledge provides impe-

tus for another discovery and holds promise for integration with other fragments to advance our understanding of ourselves and our environment. However esoteric a contribution may seem, therefore, it may be the crucial link in a future synthesis of apparently unrelated facts. Isolated facts remain for the most part irrelevant, but their accretion and coalescence often invest them with previously unrecognized aesthetic, intellectual, or material value.

The uncertainties, anxieties, disappointments, frustrations, and the self-abnegation in the daily work of the scientist test his sincerity and dedication and readily exclude the seeker of instant affluence, easy success, adulation, prestige, notoriety, or other ephemeral gains. Those with intellectual and altruistic motives and with the requisite imagination, energy, industry, perseverance, courage, and stability to meet the challenge and the responsibility find the life of science highly rewarding and its gratifications more than compensatory for its liabilities. Participation in the exciting world of inquiry and discovery is, in fact, its own reward. Fame, when it comes, may be accidental; always it is incidental—the by-product, rather than the goal, of research.

A career in science carries serious responsibility. The scientist's duty is not only to add to current knowledge, but to share his discoveries with his colleagues and the world. He has a further obligation to provide instruction, encouragement, and support to young scientists. Continued improvement of man's state depends heavily on the transmission and extension of knowledge from one generation to another. The scientist's bequest of knowledge to the next generation of scientists and the free exchange of ideas among contemporaries illustrates the primacy of humanitarian interests over self-interest and self-glorification. All of us engaged in scientific endeavors begin where predecessors stopped; no researcher starts with a *tabula rasa* or works in an intellectual vacuum. Since the most inchoate stages of science, researchers have drawn on their predecessors. The work of René Descartes, Isaac Newton, and Louis Pasteur depended heavily on the totality of previous knowledge—the discov-

eries, both significant and minute, of their contemporaries and predecessors.

The scientist's moral responsibilities are grave. Man will undoubtedly be able one day to produce future generations of human beings with pre-selected biologic characteristics. He must somehow attain the wisdom and discretion to guide him in using this formidable power. Above all, he must preserve a humane approach to science. Despite the characteristic scepticism of the scientist, few will deny that the order and beauty of life and the universe denote some deep meaning—however mysterious—perhaps never to be grasped by the human mind. Because he strives for the continual improvement of mankind, the scientist recognizes and seeks the guidance of the Omnipotent during dilemmas, when equivocal consequences of experimentation require critical decision.

Science and humanism are, of course, two ingredients of education. Whereas the humanities have a traditional association with education, science does not, especially in America. The first doctorate in science in this country was awarded at Yale University in 1861, only a century ago, and until recently most American scientists went abroad for training. In this, the most scientific age in the world's history, many college graduates have little knowledge or understanding of science. Yet scientific research directly affects all our lives. By discovering new knowledge, graduate scientists elevate our standard of living and stimulate industrial and technologic enterprises, which, in turn support our expanding and improving education. Since education produces scientists and since science is an integral part of our modern world, the growing cost of education and research makes their universal support imperative.

Educators have an obligation, not only to recognize potential scientists early and to provide a wholesome environment for their development, but to help every student have a better understanding of science, which is now an integral part of American culture. Science is dependent on and governed by society, largely by the pressing needs of our daily lives; an enlightened society can make more intelligent judgments regarding the fu-

ture status and direction of science. Even slight acquaintance with the spirit of science and indirect exposure to some of its excitement, breadth, and goals will enlist the support of the average citizen for education and scientific research. Alexis de Toqueville, in *Democracy in America*, wrote, "You may be sure that the more a nation is democratic, enlightened, and free, the greater will be the number of interested promoters of scientific genius. . . . Possessing education and freedom, men living in democratic ages cannot fail to improve the industrial part of science; and . . . henceforward all the efforts of the constituted authorities ought to be directed to support the highest branches of learning, and to foster the nobler passions for science itself."

Science may not be the final answer; it may never give us the final truth. And it requires the most judicious control; while freeing the mind from fear and ignorance

and superstition, it must not be allowed to tyrannize or annihilate humanity. With all the knowledge, comfort, convenience, and well-being science provides, man must still exercise discretion—intellectual, ethical, and moral judgment, humility, faith, compassion, reverence, and constraint—using his scientific power for benevolent rather than malevolent ends. But the possible destructive uses of scientific products do not make me fear new knowledge, for my faith is firm in the scientist as humanist. I am confident that he will direct his energies toward solving our human problems and will exercise control to prevent the diversion of scientific discoveries into destructive channels. "We must expect . . . that the future will disclose dangers," wrote Alfred North Whitehead. "It is the business of the future to be dangerous; and it is among the merits of science that it equips the future for the duties."